



Using an Infrared Library on Arduino

Created by Chris Young



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All photos, videos and wiring courtesy Kenneth Young	23

Overview

Most consumer electronic devices such as TV, cable box, DVD players and other devices use infrared signals for remote control. Each manufacturer has its own protocols for encoding the data so that signals intended for one device do not interfere with another. In an earlier tutorial by LadyAda (<http://adafru.it/eZ6>) she describes the inner working of reading IR signals from a remote and creating your own IR signals using an IR LED. Her tutorial gives you a behind-the-scenes peek at how IR works but it's a bit difficult to wrestle with all those technical details in your project.

If you're like me, you have no idea how NeoPixels work, nor the inner workings of I2C or SPI communications but you don't need to because we have libraries for that. A good code library isolates you, the application programmer, from the hardware details and the inner workings of devices and provide you with an API that makes it easy to use the hardware without knowing or caring what's going on behind the scenes.

In this tutorial we will show you how to use IRLib for receiving, decoding, and sending IR signals in your Arduino based project. We will show you how to change colors on a NeoPixel, control a servo using IR remote and send signals to your TV or cable box from an Arduino. Future tutorials will include an IR control mouse, and Internet of things remote control and controlling a robot arm.

About IR libraries

IR signals consists of a series of modulated pulses called "marks" separated by intervals called "spaces". Typically there is a long mark and space at the beginning of each signal that serves as a header. Then by varying the timing of marks and spaces, a sequence of bits is transmitted. If you had to store the precise timing of the entire signal it would take an array of up to 100 16 bit integers. In order to compare the data received to see if it was what you wanted, you would similarly need to store large arrays of data.

Fortunately the signals are sent according to very specific protocols that allow you to take this received timing data and turn it into a single binary number of up to 32 bits. The IR library collects the timing information in a buffer and then turns it into a single 32 bit value. You can then easily compare that value to the one you want.

Similarly if you want to transmit IR signals, all you need to do is pass 32 bit value to the library and tell it what protocol you want to use. It converts that value into a stream of marks and spaces with the proper headers, bit encodings and timings.

The gold standard of IR libraries is "LIRC" or Linux Infrared Remote Control which can be found at <http://www.lirc.org/> (<http://adafru.it/ez7>). It consists of drivers and a large database of information on hundreds of various remote controls. If we are using a Linux based system it's definitely the way to go. We will not be discussing that library here as we intend to focus on Arduino based systems.

In August 2009 Ken Shirriff published "IRremote" on his blog (<http://adafru.it/cJl>) and released it on GitHub (<http://adafru.it/cR1>). Then in January 2013 I released IRLib based on Ken's earlier work. This revision reorganize the code making it easier to add new protocols using object-oriented programming design in C++.

Detailed information about IRLib can be found on my blog at <http://tech.cyborg5.com/irlib/> (<http://adafru.it/ez8>). It includes an extensive user manual which is also available in the "manuals" folder of the library.. We'll use IRLib in this tutorial to help you get started.

Receiving and Decoding IR

Software installation

Installation of the IRLib library is as follows:

1. Visit the [IRLib page on GitHub \(http://adafru.it/ez9\)](http://adafru.it/ez9).
2. Select the “Download ZIP” button, or simply [click this link \(http://adafru.it/eza\)](http://adafru.it/eza) to download directly.
3. Uncompress the ZIP file after it’s finished downloading.
4. The resulting folder should be named “IRLib-master” and will contain a number of header files, IRLib.cpp and two subfolders containing a user manual and some example sketches. Sometimes in Windows you’ll get an intermediate-level folder and need to move things around.
5. Rename the folder (containing the .cpp and .h files and the examples and manual subdirectories) to “IRLib” and place it alongside your other Arduino libraries, typically in your (home folder)/Documents/Arduino/Libraries folder. Libraries should not be installed alongside the Arduino application itself.
6. Re-start the Arduino IDE if it’s currently running.

[Here’s a tutorial \(http://adafru.it/aYM\)](http://adafru.it/aYM) that walks through the process of correctly installing Arduino libraries.

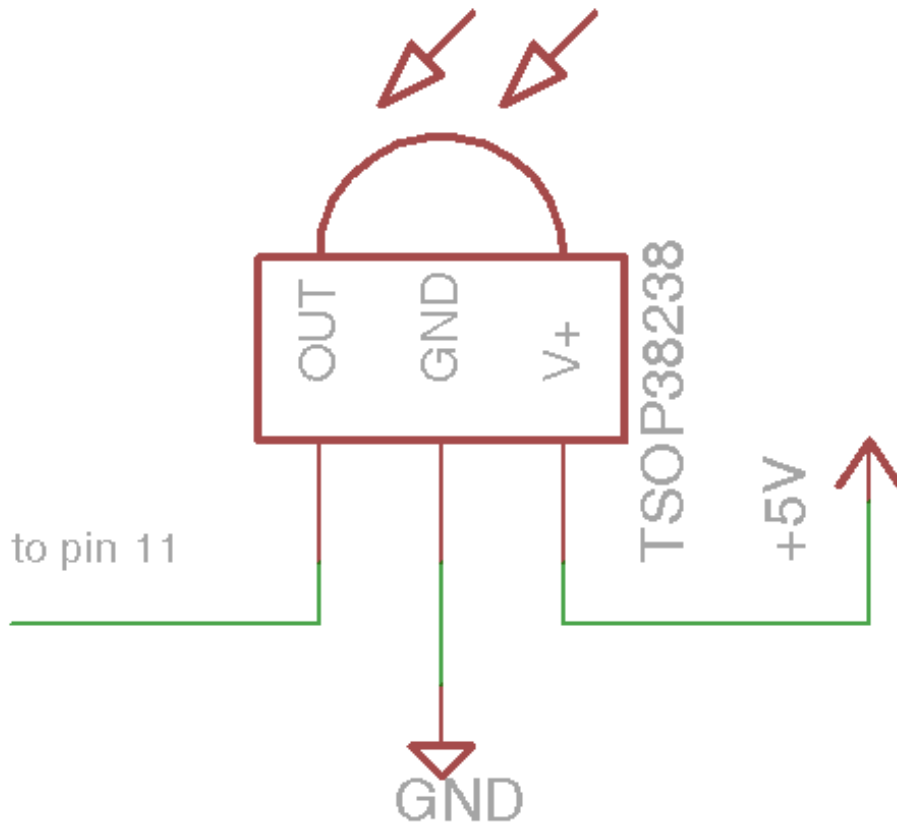
Hardware Needed

IRLib runs on 8-bit AVR based Arduino boards such as Uno, Leonardo, Mega and Micro. It also runs on the Leonardo portion of the Arduino Yun. It does not work on 32-bit ARM processors such as the Arduino Due or other Arduino-like systems. Unfortunately at this time it does not run on ATtiny85 base systems such as Adafruit Trinket and Adafruit Gemma but support for that is in the job jar and should be available in a stripped-down version for those platforms in the near future. At this writing, it has not been tested on the Adafruit Trinket Pro however since it is based on the same ATmega328 processor as the Uno, it should work fine. So the first thing you need is Arduino Uno or other compatible board.

You will need an IR receiver. Such as the TSOP38238 shown on the right column under featured products. This device combines an IR sensitive photocell, a 38 kHz bandpass filter, and automatic gain control. It operates on a variety of supply voltages including 3.3v and 5v. It de-modulates the received IR signal and gives you a nice clean square wave of off and on pulses at the voltage level of your power supply. This means it is ideal for feeding its output directly into the digital input pin of our Arduino.

Finally you will need an IR remote such as you use for controlling your TV, cable box, or DVD player. All of our examples will use the Adafruit Mini Remote Control shown on the right however we will show you how to detect what protocol your own TV remote is using and if it is a protocol supported by IRLib you can use it instead.

Connecting the IR receiver is very simple. Connect the left-hand pin to any digital input pin on your Arduino. In our examples we will use pin 11. Connect the center pin to ground and the right-hand pin to +5v.



Note that this device has a bandpass filter tuned to 38 kHz which is the typical frequency for most protocols. However some protocols use frequencies from 36 kHz all the way up to 57 kHz. The filter however is not extremely specific and we have had good success receiving anywhere from 36-40 kHz using a 38 kHz receiver. The Panasonic_Old protocol however uses 56 kHz. The TSOP38238 sold by Adafruit has difficulty decoding that frequency. I have however had good success with the receiver sold by Radio Shack at 56 kHz even though it is a 38 kHz device. Radio Shack did not list a part number but we believe it to be a TSOP4438. Sadly that may not be an option anymore :-)

These devices are made by Vishay and come in a variety of package styles, frequencies, and AGC methods. If the Adafruit device does not work for you and you need 56 kHz you can refer to the following guide.

IR Receiver Selection Guide from Vishay (PDF format)

<http://adafru.it/ezb>

More information on receivers as well as schematics for using multiple receivers can be found in the IRLib manual section 1.4.3.

Decoding IR Data

Load the following sketch. It is a slightly modified version of "IRrecvDump" sketch from the examples folder of the library.

```
#include <IRLib.h>

//Create a receiver object to listen on pin 11
IRrecv My_Receiver(11);

//Create a decoder object
IRdecode My_Decoder;

void setup()
{
  Serial.begin(9600);
  My_Receiver.enableIRIn(); // Start the receiver
}

void loop() {
  //Continuously look for results. When you have them pass them to the decoder
  if (My_Receiver.GetResults(&My_Decoder)) {
    My_Decoder.decode(); //Decode the data
    My_Decoder.DumpResults(); //Show the results on serial monitor
    My_Receiver.resume(); //Restart the receiver
  }
}
```

After the sketch has loaded, open your serial monitor and make sure it is set to 9600 baud. Aim your IR remote at the receiver and press a button. In this example we press the "Play/Pause" button on the Adafruit Mini Remote. The results were as follows:

```
Decoded NEC(1): Value:FD807F (32 bits)
Raw samples(68): Gap:40826
Head: m8850 s4450
```

```
0:m500 s600 1:m550 s550 2:m500 s600 3:m550 s600
4:m500 s600 5:m500 s600 6:m500 s600 7:m550 s550
8:m500 s1750 9:m500 s1700 10:m500 s1700 11:m550 s1650
12:m550 s1700 13:m500 s1700 14:m500 s600 15:m550 s1700
```

```
16:m500 s1700 17:m500 s600 18:m500 s600 19:m500 s600
20:m550 s600 21:m450 s650 22:m500 s600 23:m500 s600
24:m500 s600 25:m500 s1700 26:m550 s1700 27:m500 s1700
28:m500 s1700 29:m550 s1700 30:m500 s1700 31:m500 s1700
```

```
32:m500
Extent=65850
Mark min:450 max:550
```

The important part of this dump is the first line. This tells us that the protocol detected was "NEC" which is protocol number "1" in IRLib's supported protocols. The data value received was the 32-bit hexadecimal value FD807F. The rest of the information is the raw timing data of the actual marks and spaces received. That information is useful in trying to understand and supported protocols.

This 32-bit number uniquely identifies the button that you pushed. If we push the Volume down and Volume up buttons on this remote we would get the values 0xFD00FF and 0xFD40BF.

Try pressing various buttons on a TV or DVD remote you might have lying around the house. If the top line says:

```
Decoded Unknown(0): Value:0 (0 bits)
```

this means that IRLib did not understand the protocol used by your remote. Here are some typical values from other remotes. I got these from the power button on a Sony DVD player, and the play button on my Scientific Atlantic DVR/Cable Box.

```
Decoded Sony(2): Value:74BCA (20 bits)
Decoded Panasonic Old(5): Value:37990C (22 bits)
```

This shows that the DVD player used Sony protocol which is protocol number 2 and that it is a 20 bit protocol. The cable box uses Panasonic_Old protocol 5 which is 22 bits. Most protocols always use the same number of bits however some such as Sony have different versions which could use 8, 12, or 15 bits in addition to 20.

How It Works

Let's look at what's going on here. The receiver object listens to the IR sensor and when it sees a signal it starts measuring the timing of the marks and spaces. If a particular amount of time passes with no additional signals, it presumes that the data is complete and when you call `My_Receiver.GetResults` it returns "true". It passes the data to your decoder object. The decoder

uses the timing information and the number of bits to see if it matches one of the supported protocols. If it succeeds, it returns "true" although in this sketch we did not bother to check that first.

You can access the protocol number in `My_Decoder.decode_type`, the number of bits in `My_Decoder.bits` and the the decoded data value in `My_Decoder.value`.

At the top of the sketch we created the decoder object as type "IRdecode". This is a class which incorporates all seven of the supported protocols. If you're using the library to control a device such as a servo or turn relays off and on, you probably are going to be using one remote with one protocol. Once you know which protocol you are using, you may wish to use a different decoder class that only works for your particular protocol. It can save valuable program space in your sketch. For example if we were using the Adafruit Mini Remote which uses NEC protocol would change line #7 to read:

```
IRdecodeNEC My_Decoder;
```

Protocol Specific Issues

IRLib supports 7 protocols directly and includes example code on how to implement 4 others. As stated earlier, one of the jobs of a library is to isolate the application programmer from the need to deal with internal issues. However there are some protocol specific things that you may need to deal with.

The protocols are enumerated in `IRLib.h` at approximately line 60 as follows.

```
typedef char IRTYPES; //formerly was an enum
#define UNKNOWN 0
#define NEC 1
#define SONY 2
#define RC5 3
#define RC6 4
#define PANASONIC_OLD 5
#define JVC 6
#define NECX 7
```

Here are some protocol specific issues you may have to deal with.

NEC Repeat Codes

The NEC protocol uses a special sequence of marks and spaces that mean "I held down the button so you should repeat whatever I sent you last time". It is up to you to decide do I want to allow repeat codes or do I want to force the operator to push and release the button each time. IRLib returns a value of `0xFFFFFFFF` to tell you that the special repeat sequence was received. You can

ignore that sequence which forces the user to release and repress the button each time or you can store the previously received code and process it whenever you see the special repeat message.

Sony Triple Messages

The technical specification for Sony protocol says that you should send each code 3 consecutive times per keypress. IRLib takes care of sending three times for you so you don't need to do anything special. However when receiving Sony, be aware that you're going to get three copies of the data each time the user presses a button. If you're busy processing the first sequence you might miss the other two so it won't matter. But you need to be aware of it in case you're counting the number of keypresses or some other application.

RC5 and RC6 Toggle Bits

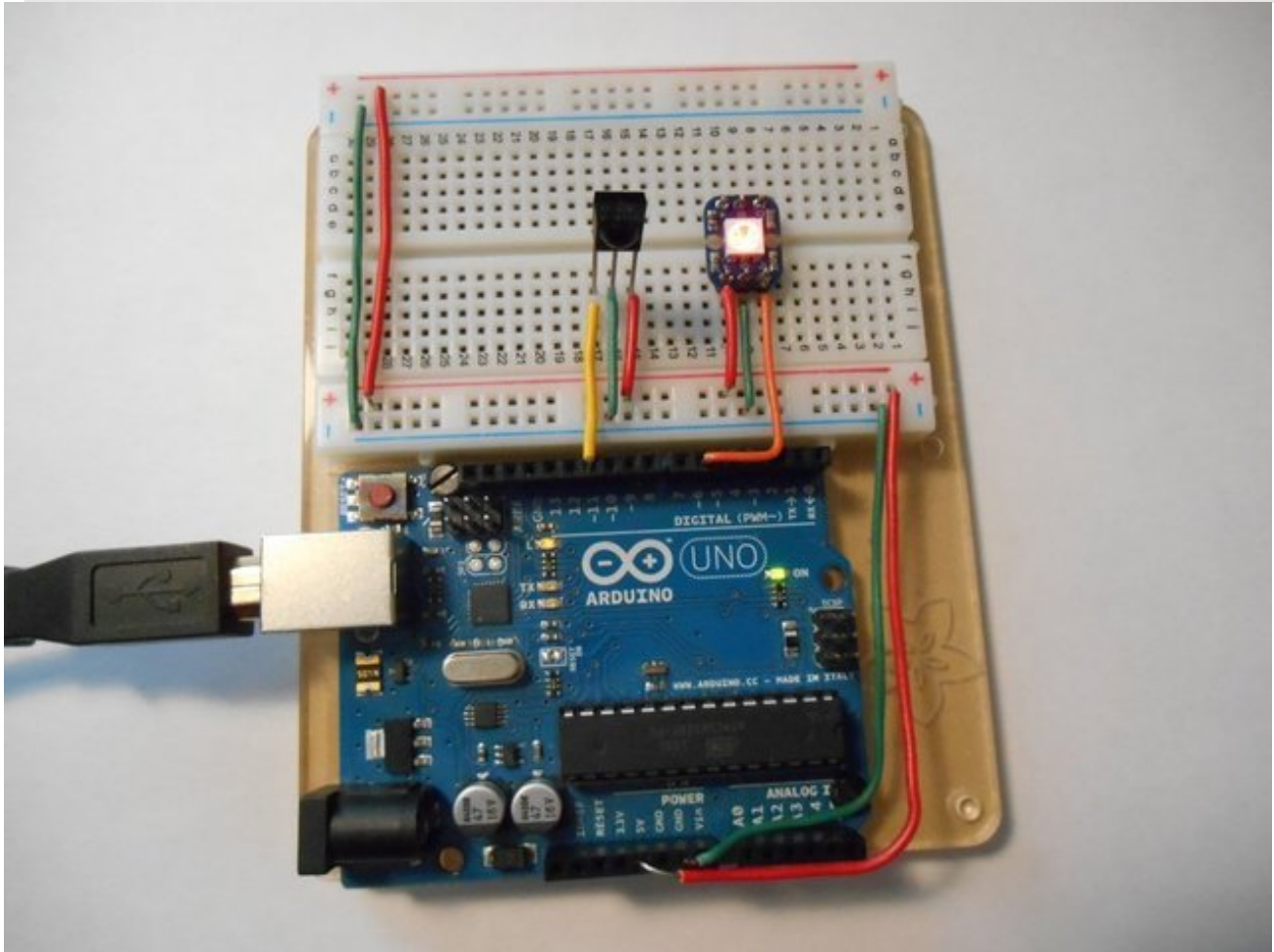
The RC5 and RC6 protocols invented by Phillips use a special toggle bit to let you know whether a code was generated by holding down the button or whether this is an independent keypress. For example I have a TV which uses RC5 protocol and the code for Volume Up is 0x1010. If I press and hold that button it sends the same code repeatedly. However if I release the button and press it again I get 0x1810. Every other keypress the single bit 0x0800 will toggle off and on. You can make sure that you ignore this feature by masking out that particular bit. When you receive a decoded value from this protocol you could do:

```
My_Decoder.value &=0xf7ff;
```

This will make sure that the toggle bit is always off. The RC6 protocol also has a title bit which is 0x10000. Therefore to mask it out you would do:

```
My_Decoder.value &=0xfeffff;
```

Controlling NeoPixels with IR



In this very simple example we will change the color of a NeoPixel by pushing buttons on the remote. We are using a single pixel but you can modify the sketch to control an entire strip or matrix. For more information on NeoPixels [visit this guide in the Adafruit Learning System](http://adafru.it/dYa) (<http://adafru.it/dYa>). Here is the code:

```

#include <Adafruit_NeoPixel.h>
#include <IRLib.h>

IRrecv My_Receiver(11); //receiver on pin 11
IRdecode My_Decoder; //Decoder object

//One NeoPixel connected to pin six
Adafruit_NeoPixel strip = Adafruit_NeoPixel(1,6,NEO_GRB + NEO_KHZ800);

void setup() {
  strip.begin();
  strip.show(); // Initialize all pixels to 'off'
  My_Receiver.enableIRIn(); // Start the receiver
}

void loop() {
  if (My_Receiver.GetResults(&My_Decoder)) {
    My_Decoder.decode();
    if (My_Decoder.decode_type== NEC) {
      switch(My_Decoder.value) {
        case 0xfd00ff: //Volume Down
          strip.setPixelColor(0,255,0,0); //Red
          break;
        case 0xfd807f: //Play/Pause
          strip.setPixelColor(0,0,255,0); //Green
          break;
        case 0xfd40bf: //Volume Up
          strip.setPixelColor(0,0,0,255); //Blue
          break;
      }
      strip.show();
      My_Receiver.resume(); //Restart the receiver
    }
  }
}

```

We create a NeoPixel strip with one pixel connected to pin 6. Also create a receiver object connected to pin 11 and a decoder object. Reinitialize the pixel strip and the IR receiver in the setup routine. Then in the main loop continuously test the receiver to see if it has received many IR signals. If `My_Receiver.GetResults` returns true then we decode the data. We are using the Adafruit Mini Remote we used earlier. It used the NEC protocol so we make sure that we actually received NEC protocol data. Then we use a switch statement to test various 32-bit hex values against the decoded data in `My_Decoder.value`.

After we have set the pixel color based on the received value, we need to call `strip.show()` to

actually change the color and `My_Receiver.resume()` to reset the receiver so it can collect another code.

Upload the sketch and try pressing the volume down, play/pause, and volume up buttons. You should see the pixel change to red, green, or blue. You can easily add additional case statements and colors or perhaps have one of the cases call an animation routine to animate the entire strip of pixels. Different buttons on the remote would select different animation patterns.

You will have to modify this sketch if you are using a different remote control. Change the protocol type such as:

```
if (My_Decoder.decode_type==SONY)
```

for example if you are using a Sony remote. And of course you have to substitute the proper codes in each case statement. The enumerated list of available protocols for comparing `decode_type` can be found at approximately line 60 of `IRLib.h`.

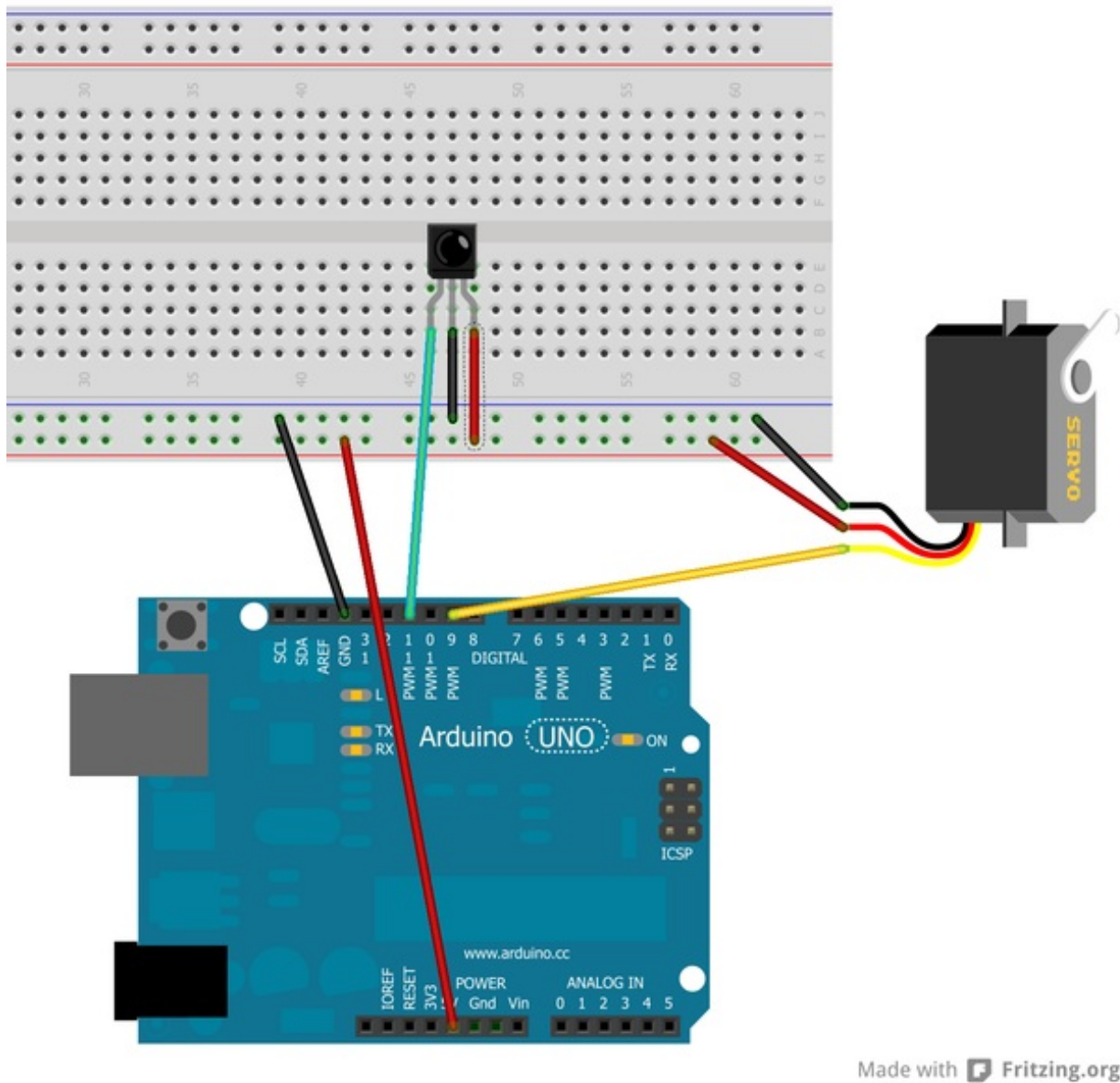


Controlling a Servo with IR

Setting up the Example

In this example we will control the servo using an IR remote. We can adjust the speed that the servo moves and we can select individual preset angles for positioning the servo.

Here is an illustration showing how to wire up the devices. As usual we have an IR receiver connected to +5v, ground, and pin 11. We also have a servo with three wires. The red wire is +5v. The black or dark brown wire is ground and the remaining wire usually yellow is the signal wire which we have connected to pin 9 although it could be any digital output pin.



Upload the Code

Below is a version of the IRservo.ino sketch from the IRLib examples folder. It has been modified to be used with the Adafruit Mini Remote. If you're using a different remote, you will have to collect information about your codes for various buttons using IRrecvDump and modify the sketch with the proper protocol name and codes.

```
#include <IRLib.h>
#include <Servo.h>

// You will have to set these values depending on the protocol
// and remote codes that you are using. These are For the Adafruit
// Mini Remote
#define MY_PROTOCOL NEC
#define RIGHT_ARROW 0xfd50af //Move several clockwise
#define LEFT_ARROW 0xfd10ef //Move servo counterclockwise
#define SELECT_BUTTON 0xfd906f //Center the servo
#define UP_ARROW 0xfda05f //Increased number of degrees servo moves
#define DOWN_ARROW 0xfdb04f //Decrease number of degrees servo moves
#define BUTTON_0 0xfd30cf //Pushing buttons 0-9 moves to fixed positions
#define BUTTON_1 0xfd08f7 // each 20 degrees greater
#define BUTTON_2 0xfd8877
#define BUTTON_3 0xfd48b7
#define BUTTON_4 0xfd28d7
#define BUTTON_5 0xfda857
#define BUTTON_6 0xfd6897
#define BUTTON_7 0xfd18e7
#define BUTTON_8 0xfd9867
#define BUTTON_9 0xfd58a7

IRrecv My_Receiver(11); //Receive on pin 11
IRdecode My_Decoder;
Servo My_Servo; // create servo object to control a servo
int pos; // variable to store the servo position
int Speed; // Number of degrees to move each time a left/right button is pressed
long Previous; // Stores previous code to handle NEC repeat codes
void setup()
{
  My_Servo.attach(9); // attaches the servo on pin 9 to the servo object
  pos = 90; // start at midpoint 90 degrees
  Speed = 3; // servo moves 3 degrees each time left/right is pushed
  My_Servo.write(pos); // Set initial position
  My_Receiver.enableIRIn(); // Start the receiver
}

void loop()
```



```

{
  if (My_Receiver.GetResults(&My_Decoder)) {
    My_Decoder.decode();
    if(My_Decoder.decode_type==MY_PROTOCOL) {
      if(My_Decoder.value==0xFFFFFFFF)
        My_Decoder.value=Previous;
      switch(My_Decoder.value) {
        case LEFT_ARROW:  pos=min(180,pos+Speed); break;
        case RIGHT_ARROW: pos=max(0,pos-Speed); break;
        case SELECT_BUTTON: pos=90; break;
        case UP_ARROW:    Speed=min(10, Speed+1); break;
        case DOWN_ARROW:  Speed=max(1, Speed-1); break;
        case BUTTON_0:    pos=0*20; break;
        case BUTTON_1:    pos=1*20; break;
        case BUTTON_2:    pos=2*20; break;
        case BUTTON_3:    pos=3*20; break;
        case BUTTON_4:    pos=4*20; break;
        case BUTTON_5:    pos=5*20; break;
        case BUTTON_6:    pos=6*20; break;
        case BUTTON_7:    pos=7*20; break;
        case BUTTON_8:    pos=8*20; break;
        case BUTTON_9:    pos=9*20; break;
      }
      My_Servo.write(pos); // tell servo to go to position in variable 'pos'
      Previous=My_Decoder.value;
    }
    My_Receiver.resume();
  }
}
}

```

NOTE: If using Leonardo, Micro, or Yun or other ATmega32u4 System, See the special instructions at the end of this page.

Upload the sketch and try pushing the left and right arrow buttons. The servo should turn left and right. Pushing the enter button should center the servo. Pushing the up or down arrow buttons will not have any visible effect but it will change the speed of movement you push left or right. The numbered buttons from zero through nine move the servo to 10 different fixed positions at 20° intervals.

If the servo behaves erratically, it may be a power supply problem. Some USB ports do not deliver sufficient current to drive the Arduino and move the servo. You may need to add an external 5 volt supply. Here is a video demonstrating this example.

How It Works

The program creates a receiver on object, a decoder object and a servo object. You can find more information on the [standard Arduino Servo library here \(http://adafruit.it/ecQ\)](http://adafruit.it/ecQ). The setup function attaches the servo, enables IR input, and initializes several variables.

The loop function gets an IR code and passes it to a switch statement depending on its value. Each case of the switch statement handles a different function moving the servo as needed.

There is one bit of overhead we need to take care of because we are using NEC protocol. That protocol has a unique feature that allows you to see if the button on the remote has been held down to send repeated instances of the same value. It has a special sequence of marks and spaces that mean "Repeat what you did last time". When IRLib sees the special sequence, it returns the value 0xFFFFFFFF. We take care of that special case by storing the previous value at the bottom of the switch statement so that if we get a repeat code we can substitute it the next time. NEC protocol is the only protocol that uses this particular method for detecting repeat codes. Other protocols have other systems which are explained in detail in the IRLib documentation.

Special Instructions for ATmega32u4 based systems

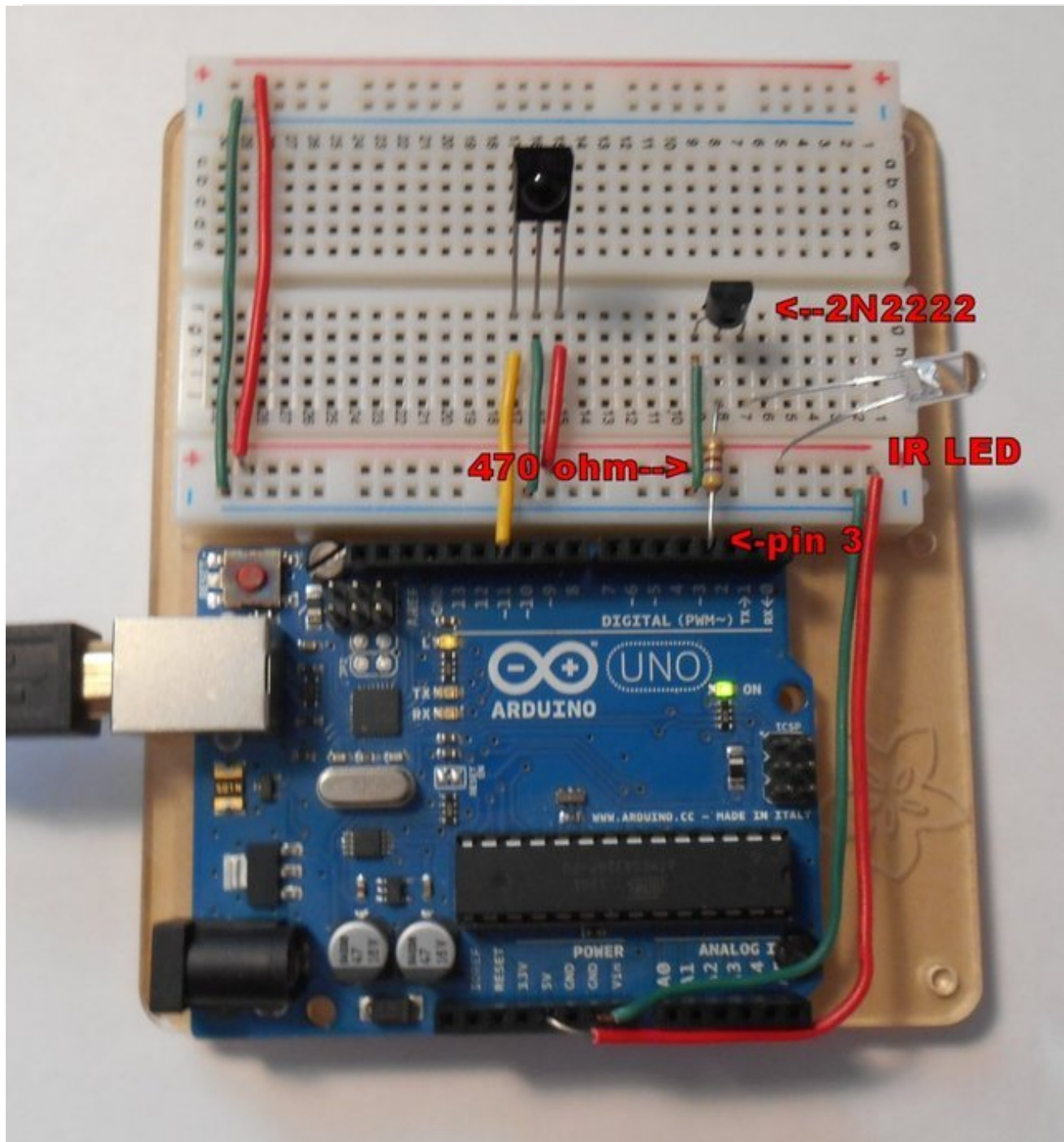
The example as presented here should work okay on Arduino Uno or Mega however if you are using Arduino Leonardo, Arduino Micro, Arduino Yun or other ATmega32u4 based systems, you will have to make a slight modification to IRLib.

IRLib uses your Arduino's built in hardware timers to generate an interrupt every 50µs so it can poll the input pin to see if it has changed. By default it uses TIMER2. The Arduino servo library also uses hardware interrupts using TIMER1. However the ATmega32u4 processor does not have TIMER2 so IRLib defaults to TIMER1 on systems using that processor. You will have to modify IRLibTimer.h to change the default timer. In that file at approximately line 70 you will see something like this:

```
#elif defined(__AVR_ATmega32U4__)
#ifdef CORE_TEENSY
  // it's Teensy 2.0
  //#define IR_SEND_TIMER1 14
  //#define IR_SEND_TIMER3 9
  #define IR_SEND_TIMER4_HS 10
#else
  /* it's probably Leonardo */
  #define IR_SEND_TIMER1 9
  //#define IR_SEND_TIMER3 5
  //#define IR_SEND_TIMER4_HS 13
#endif
```

You will need to put `//` in front of `#define IR_SEND_TIMER1` to comment out that line. Then remove the slashes from in front of one of the other two options either `TIMER3` or `TIMER4_HS`. Note that these defines say `"IR_SEND_TIMERxx"`. Later in the file we copy this value to also be used as the receiving timer. If you're using Leonardo and you later use `IRLib` to send IR signals you will need to make note of the numbers after these defines. Although we can hook a receiver to any digital input pin, `IRLib` requires you to use specific output pins depending on which timer you are using. Will cover that later in the section on sending.

Sending IR Codes



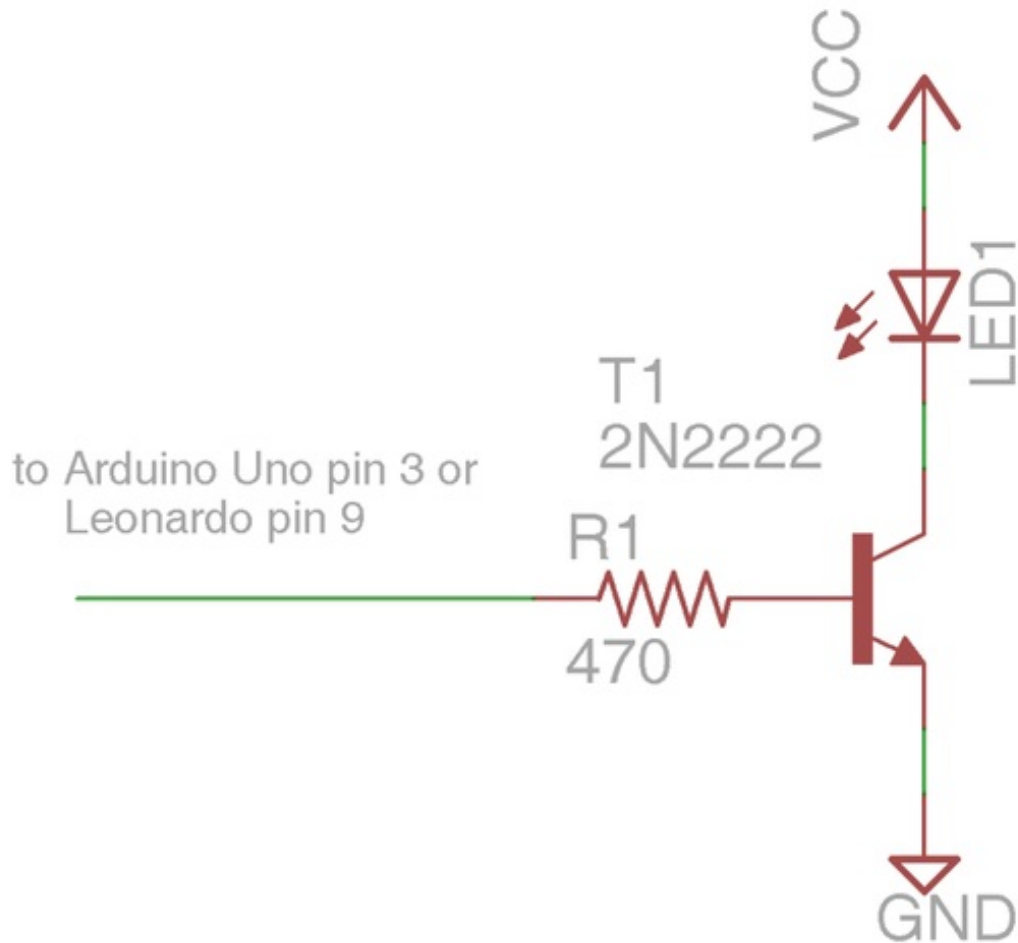
Hardware Issues

IRLib not only receives and decodes IR signals but it can transmit them as well using an IR LED and a driver circuit. The library has been used to control TVs, cable boxes, DVDs, VCRs, and IR controlled toys such as helicopters and dinosaur robots.

It could also be used to control some home automation devices. Some users have attempted to

control air conditioners and fans however protocols used for air-conditioners are extremely difficult to implement and we have not directly supported such protocols because they are very rare.

Typically the output pin of an Arduino cannot supply sufficient current to drive an IR LED so you will want to implement a simple driver circuit using an NPN transistor and a 470 ohm resistor is shown here:



Make sure that you get the polarity of the LED correct. The shorter of the two leads connects to the transistor and the longer one connects to the positive supply. Note that the current passing through the LED will in all likelihood will exceed the maximum continuous current rating. However because the signal is modulated and sending a sequence of pulses that will only last a few milliseconds the circuit will work fine.

More advanced driver circuit schematics are available in the IRLib manual in section 1.4 Hardware Considerations.

While we can connect an IR receiver to any available digital input pin, you can only use very specific pins for output. The library uses PWM pins and modifies the timing parameters to change the default frequency of that pin.

The default timer is TIMER2 on the Arduino Uno and Arduino Mega. On the Leonardo with is TIMER1. The pin numbers are pin 3 for Uno and use pin 9 for the Leonardo and Mega. If you have modified the library to use a different timer such as changing the timer number on a Leonardo to avoid conflicts with the servo library, then you will need to use a different specific pin. See section 1.4.1 Supported Platforms in the IRLib users manual for a table which shows the relationship between hardware timers and pin numbers.

Loading the Software

We presume you have already installed the IRLib library as described earlier in this tutorial. Let's load a simple sketch and see how it works. This is the IRsendDemo sketch from the examples folder.

```
#include <IRLib.h>

IRsend My_Sender;

void setup()
{
  Serial.begin(9600);
}

void loop() {
  if (Serial.read() != -1) {
    //send a code every time a character is received from the serial port
    //Sony DVD power A8BCA
    My_Sender.send(SONY,0xa8bca, 20);
  }
}
```

In this somewhat trivial example we send the code to turn on and off a Sony DVD player every time you type a character into the serial monitor. We create a sending object My_Sender. There is no set up except to initialize the serial port. In the loop we check for incoming characters and if we've got one we send the code.

The send method has three parameters: the protocol type, the data, and the number of bits.

The IRsend object we created is a generic routine that supports all seven protocols. However in this case since we are only using one protocol we could've created the object using:

```
IRsendSony My_Sender;
```

Inside the loop the send command would then be:

```
My_Sender.send(0xa8bca, 20);
```

Some protocols such as NEC always use the same number of bits and so you do not need to specify as an additional parameter. See the prototypes in IRLib.h and the users manual to see if the extra bits parameter is required.

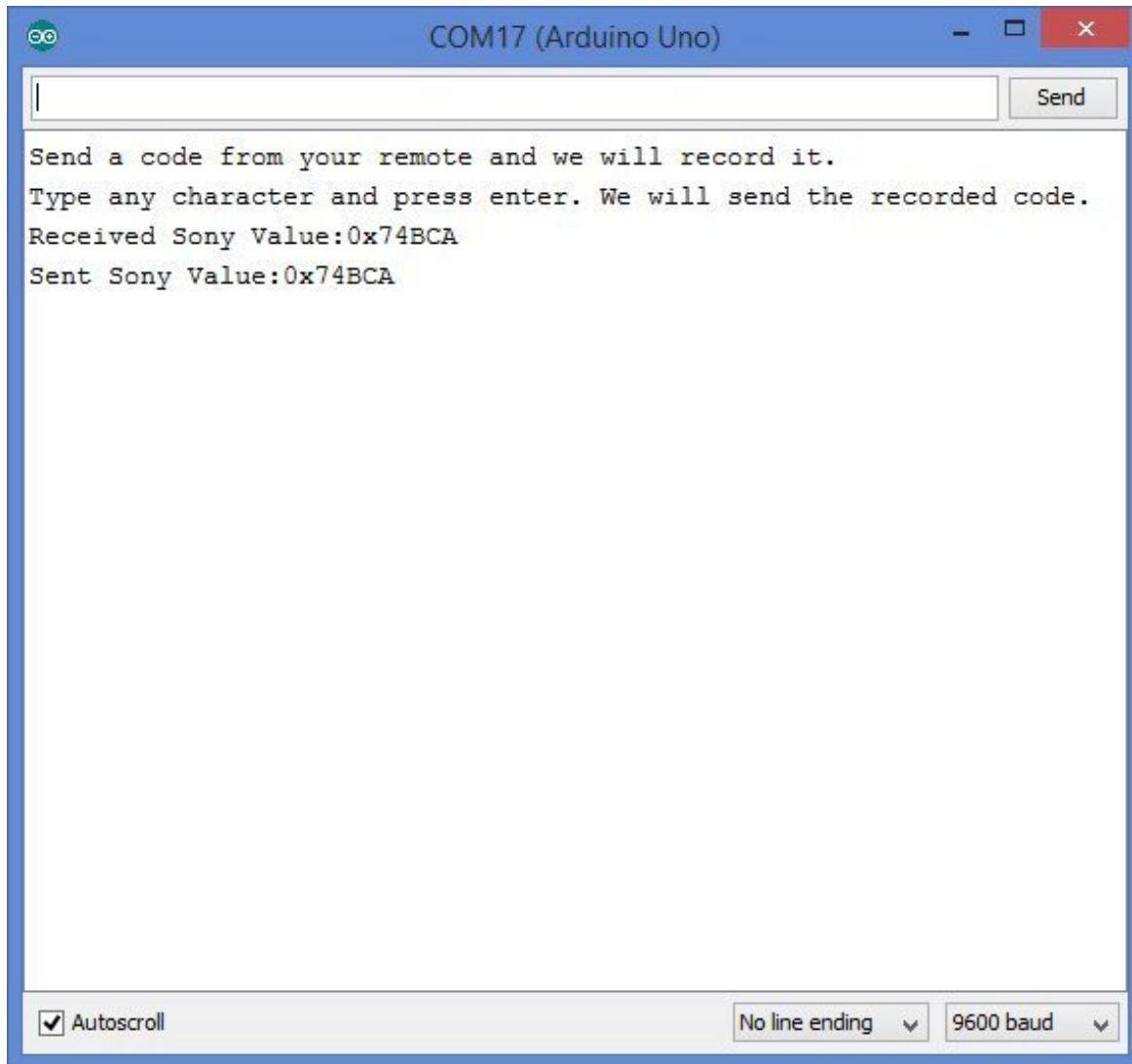
Sending and Receiving in the Same Program

There are special considerations when doing sending and receiving in the same program. Both sending and receiving make use of the building hardware timers. However the timer is used for two different purposes. When you send a code, it reconfigures the timer and disables receiving. So you have to reenable your receiver after each send. For example:

```
My_Sender.send(Protocol, Data, Bits);  
My_Receiver.enableIRIn(); // Re-enable receiver
```

Normally you would only need to call `My_Receiver.enableIRIn()`; once in the setup routine but if you are both sending and receiving you have to call it after each send.

For a complete example of how to send and receive in the same program, look at the `IRrecord.ino` sample sketch in the examples folder. When you load the sketch, open your serial monitor, point a remote at the receiver and push a button. The program will capture that code. Then every time the type of character into the serial monitor it will repeat that code through the LED.



In a separate tutorial we will show you how to use IRLib to create your own universal remote by either sending data through the serial port into the Arduino or by creating a web-based universal remote using Arduino Yun.

All photos, videos and wiring courtesy Kenneth Young